Cloud and Boundary Layer CPT

NCEP: Jongil Han (PI), Ruiyu Sun

GFDL: Chris Golaz (PI), Ming Zhao

JPL: Joao Teixeira (PI), Marcin Witek

U. Washington: Chris Bretherton (Lead PI), Chris Jones, Peter Blossey

Goals

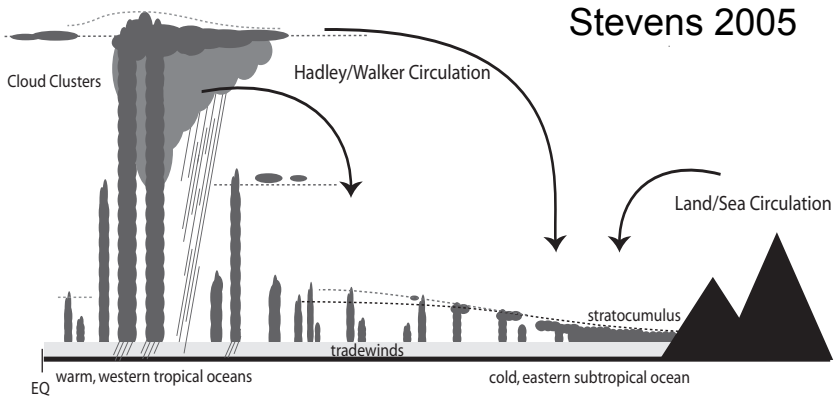
Building on previous results of Sc-Cu CPT,

- Implement a moist Eddy-Diffusion Mass-Flux (EDMF) scheme within GFS that improves operational weather and coupled climate metrics (JPL, NCEP, UW).
- Improve global cloud climatology of GFS+MOM through better cloud microphysical and macrophysical schemes (NCEP, UW).
- Compare GFS-forecast clouds with versions of GFDL climate model run in initialized weather forecast mode (NCEP, GFDL, UW).

Context: NOAA Sc-Cu Transition CPT (2010-2013)

Goal: Improve the representation of the cloudy boundary layer in NCEP GFS and NCAR CAM5 with a focus on the subtropical stratocumulus to cumulus (Sc-Cu) transition

NCEP H. Pan (PI), J. Han, R. Sun
NCAR S. Park (PI), C. Hannay
JPL J. Teixeira (CPT lead PI), M. Witek
UW C. Bretherton (PI), J. Fletcher, P. Blossey
UCLA R. Mechoso (PI), H. Xiao
LLNL S. Klein (PI), P. Caldwell



Key GFS diagnostic findings (Xiao et al. 2014):

1. GFS and CFSv2 have too little cloud almost everywhere
2. GFS loses 5-10 W m^{-2} from neglect of TKE dissipation heating
3. GFS subtropical Sc maxima are too far offshore.
4. Otherwise, GFS+MOM makes an excellent climate model

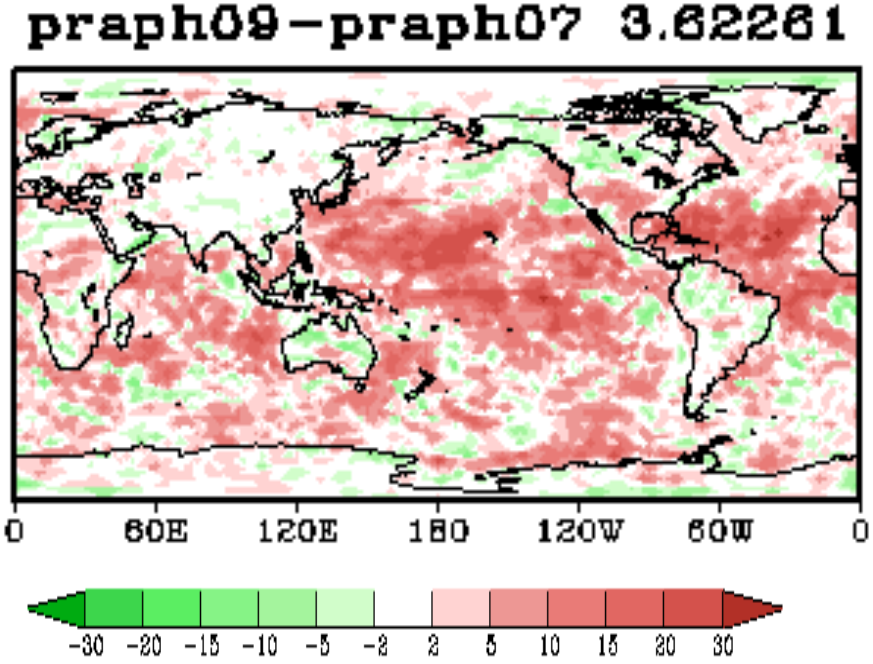
Sc-Cu CPT model improvement work

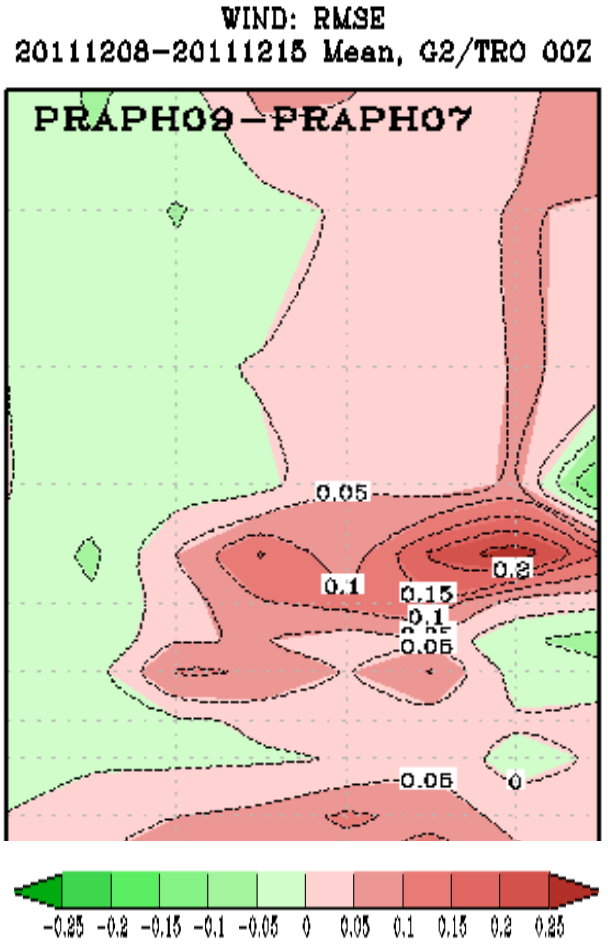
1. Developed new unified cloud fraction scheme (Pan and Han) in place of separate schemes for radiation, microphysics. This increases global cloud cover in parallel forecast tests
2. Showed that LES-suggested changes to shallow cumulus parameterization also increase global cloud cover (Fletcher et al. 2014).
3. Added TKE dissipation heating scheme (Han and Pan)
4. Implemented ‘dry’ EDMF scheme in GFS (JPL, Han)

- These all underwent parallel forecast testing with mixed results (none affects 500 mb RMSE; hard to improve all of tropical winds, US precipitation and clouds).
- A basket of moist physics changes including forms of 3 and 4 are in GFS pre-operational testing.

Shortrun2 DA test (moist physics/Cu param changes): Cloud cover increase, but degrades tropical winds

shortrun2 - control cloud cover



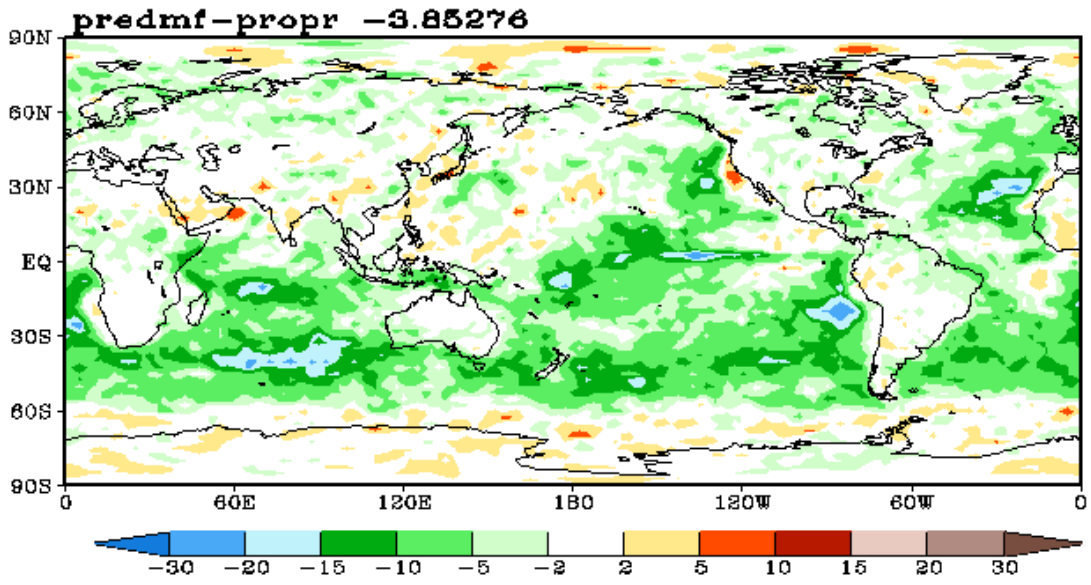


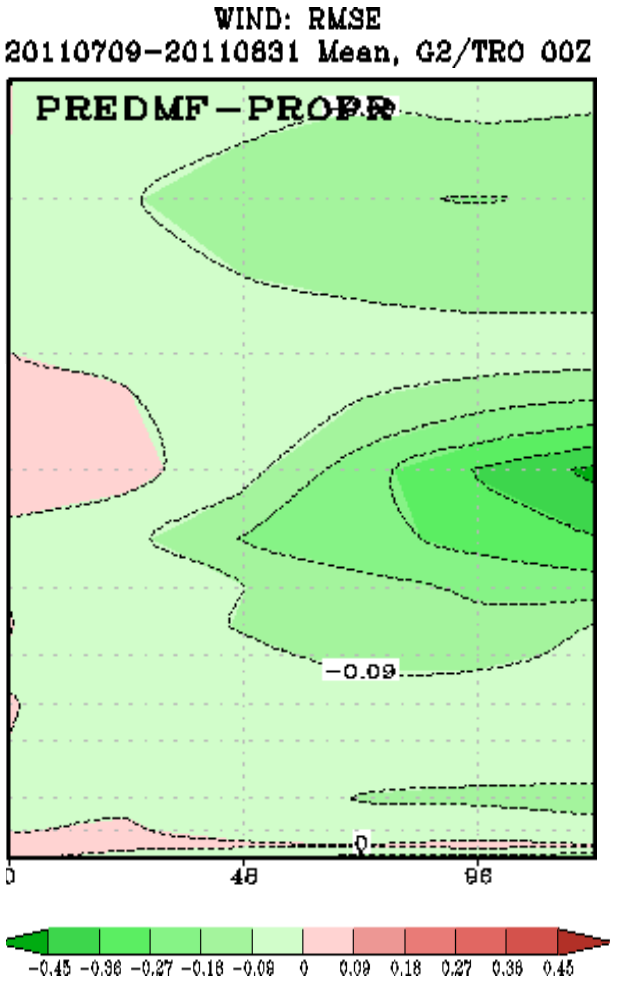
Forecast/DA test of 'dry' EDMF

EDMF: $$\overline{w'\varphi'} = -k\frac{\partial\bar{\varphi}}{\partial z} + M(\varphi_u - \bar{\varphi})$$

Dry EDMF: Transport 'dry' thermodynamic variables φ = θ and q_v; no latent heating in turbulent motions.

- Similar to current EDCG PBL scheme
- Can't mix thru moist-adiabatic cloud layer; tends to underdeepen PBL.





- Low cloud decrease but reduced tropical wind errors.

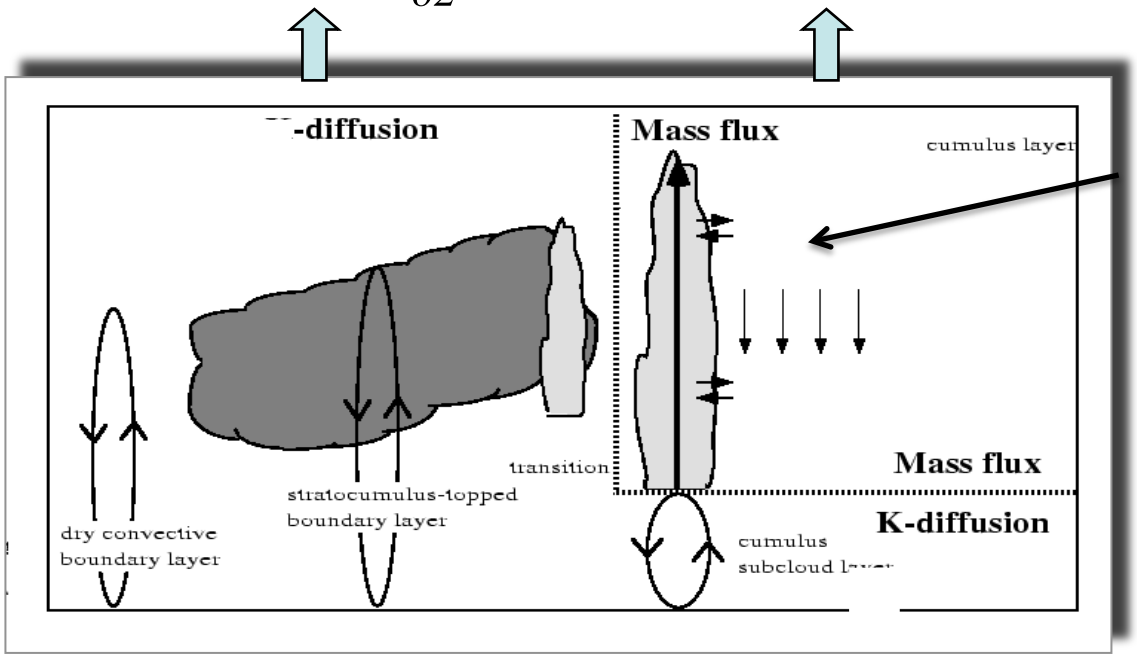
Current status and plans

We are mostly in $1K funding hiatus, but some work goes on:

Main short-term focus: GFS implementation of 'moist' EDMF:

Transport moist variables $\varphi = \theta_l$ and q_t, dealing with Sc-top entrainment and merging with mass-flux Cu param. Much more challenging but rewarding to get right than dry EDMF.

$$\overline{w'\phi'} \cong -K\frac{\partial\bar{\phi}}{\partial z} \qquad \overline{w'\phi'} \cong M(\phi_u - \bar{\phi})$$



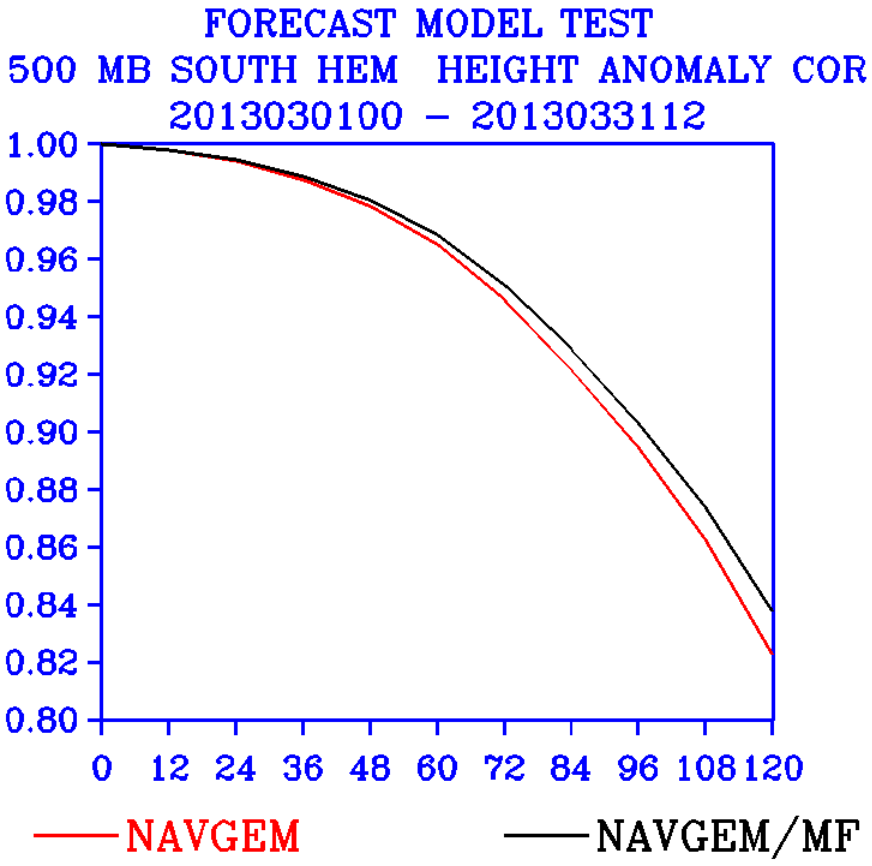
JPL EDMF uses multiple Cu plumes with stochastic entrainment

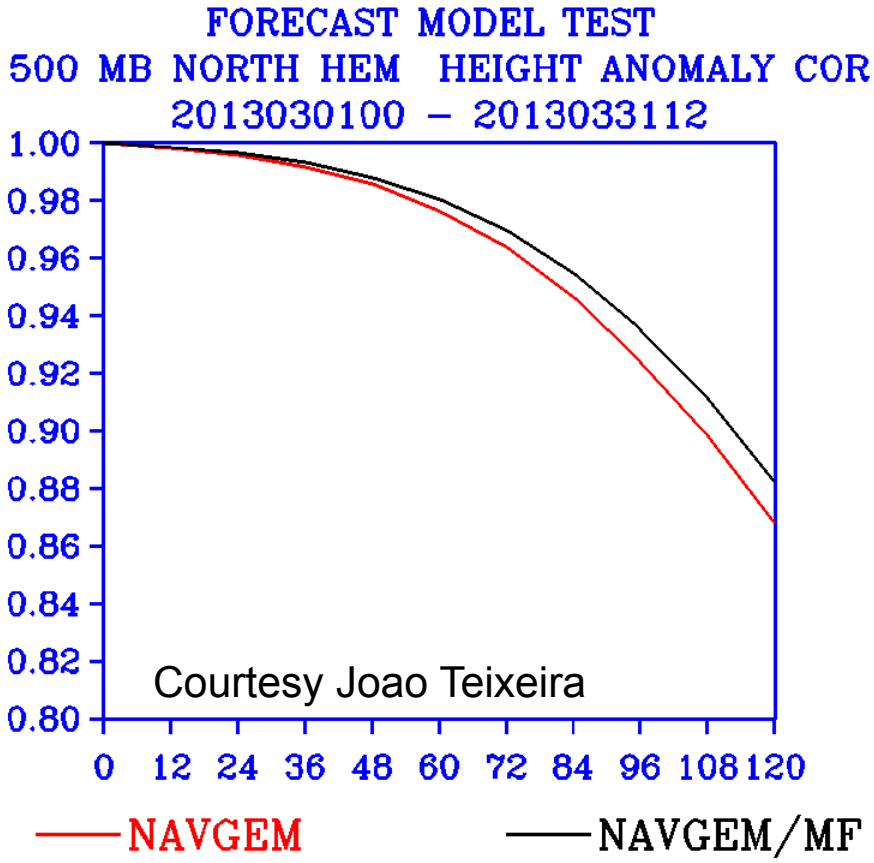
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Stochastic Moist EDMF implementation into US Navy global model NAVGEM

Southern and Northern Hemisphere 500 hPa Anomaly Correlations for NAVGEM and NAVGEM with EDMF - Full data assimilation (T359L50)





Stochastic EDMF significantly improves Navy NAVGEM model

Conclusions/Thoughts

- Working on moist EDMF to integrate turbulence and Cu.
- Some similarities to HOC approach of UU/CSU CPT.
- The two groups should work together on SCM diagnostics and global testing framework and have common meetings
- Pure weather forecast testing may not favor cloud simulation improvements beneficial for CFS, so metrics discussion would be useful.
- The GFDL parallel forecasts should expose areas of relative GFS strength vs, weakness in cloud forecasting, but not much will happen until funding starts ~ May.